Cost-effectiveness of Investments in Defense of Critical Infrastructure

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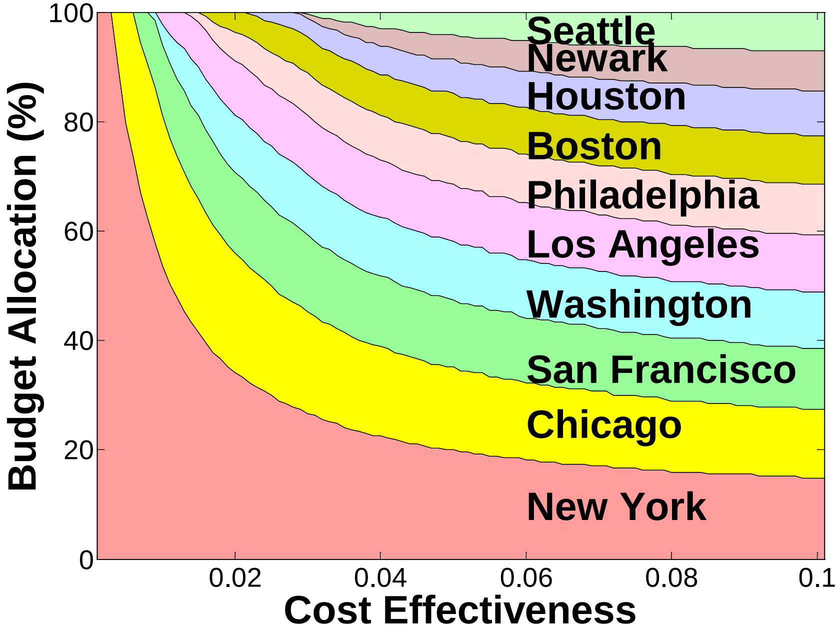
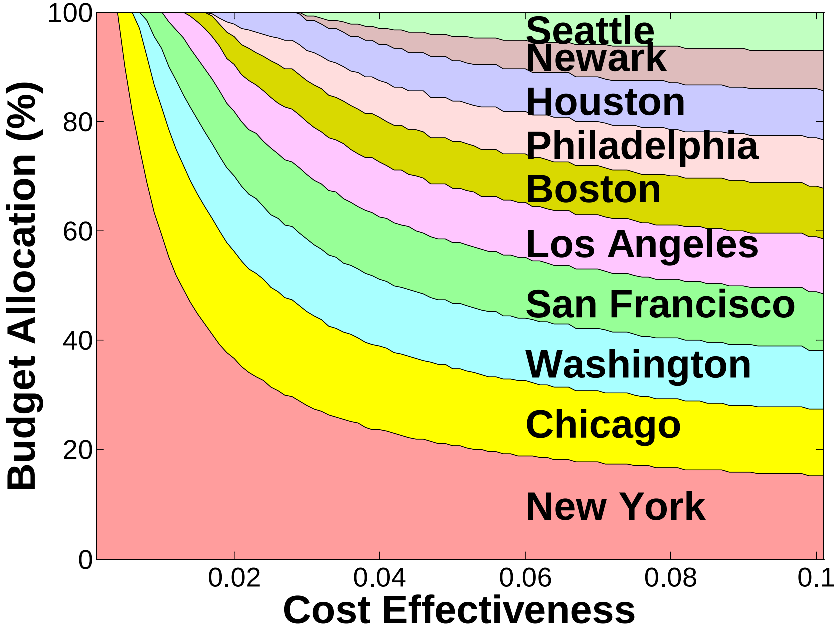
Impact of Cost Effectiveness



Property losses as a measure of target attractiveness



Fatalities as a measure of target attractiveness

Analysis of Results

- Cost effectiveness of defensive investments has a major effect on the optimal resource allocation
- When investment is not highly cost effective:
  - All or most of the budget should go to most attractive target(s)
- As the cost effectiveness increases:
  - Smaller targets get more funding
  - But the most attractive target still gets a larger share
- Different measures of attractiveness yield different optimal budget allocations

Motivation

- Cost effectiveness of defensive investment has an enormous impact on optimal allocation of defenses:
  - But we do not yet have good estimates of cost effectiveness
- I will present quantitative estimates of the cost-effectiveness of investments in protection and resilience:
  - Based on observed reductions in estimated criticality after the expenditure of security funds

Data

- Wisconsin Office of Justice Assistance (OJA) provided:
  - A sanitized list of critical infrastructures and key resources
  - The dollar amount spent by each site (from $0 to $485,000)
  - Each site's before and after criticality scores (from 36 to 56, on a scale of 0 to 100)
- Data included assets in the following sectors:
  - Hazardous Materials
  - Water
  - Commercial
  - Transportation
  - Government

Criticality Scores

- Criticality scores were developed using the Critical Asset Risk Evaluation System (CARES) developed by IEM.
- CARES is an automated risk-assessment tool that helps users analyze and compare relative infrastructure risks, using the basic DHS risk-management methodology:
  - ***RISK = THREAT × VULNERABILITY × CONSEQUENCE***

Criticality Scores

- ***THREAT***
  - Threat Indicators
  - Threat History
- ***VULNERABILITY***
  - Access Denial
  - Threat Detection
  - Incident Termination

Criticality Scores

- ***CONSEQUENCE***
  - Death and Injury
  - Public Health, Safety, and Security
  - Economic Impact
  - Government Operations
  - Psychological Influence, Public Confidence, and Morale
  - Destruction of Property
  - Environment Impact
  - Impact on Additional Critical Infrastructure

Statistical Analysis

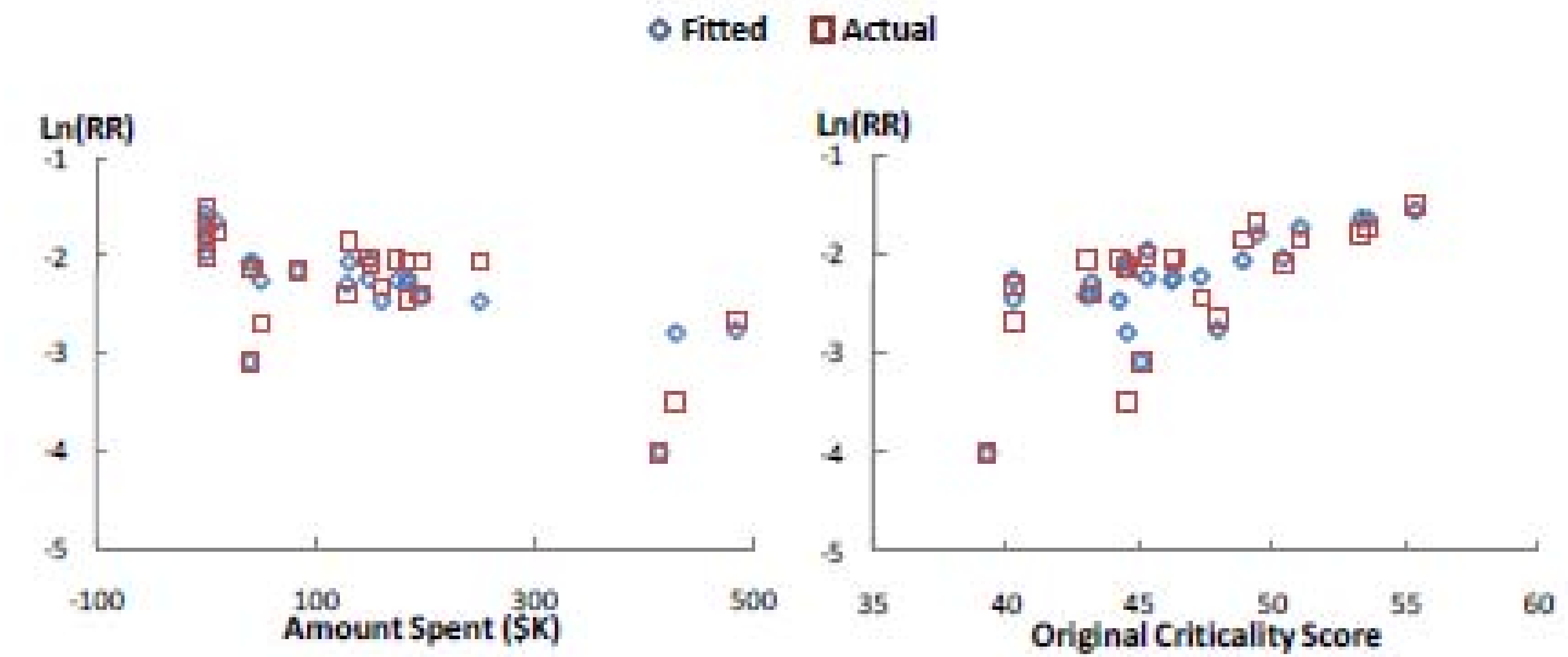
- Dependent Variable:
  - ***Risk Reduction (RR) = 1 – Final Score (F)/Original Score (O)***
- Statistically Significant Independent Variables:
  - ***Intercept***
  - ***S: Amount Spent (in thousands of dollars)***
  - ***O: Original Criticality Score***
  - ***T: Transportation Sector (binary variable)***

Fitted Regression Model

- ***Ln(RR)* = –** 3.75 **–** 0.0019 ***S* +** 0.0395 ***O* –** 1.04 ***T***
  - *Std. error: (0.68) (0.0004) (0.0140) (0.20)*
- ***RR* =** $0.023\,(0.998^{S})\,(1.04^{O})\,(0.35^{T})$
- ***Adjusted*** R^2 *= 0.80*
- Example:
  - If the original criticality score (***O***) is 50
  - The amount spent is \$100,000 (***S*** = 100)
  - The asset is not transportation (***T*** = 0)
- Then the risk reduction is estimated to be:
  - $\mathbf{(0.023)\,(0.998^{100})\,(1.04^{50})\,(0.35^{0}) =}$
  - **0.023 (0.82) (7.11) (1)** = **0.13**

Fitted Regression Model

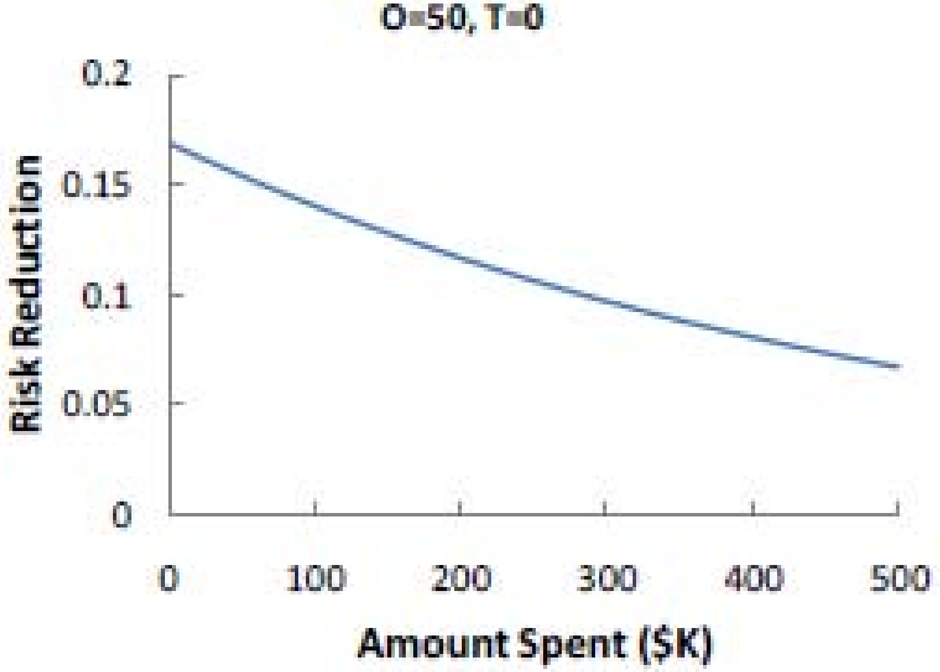
- **Reasonable fits were achieved:**



- Results were also quite robust with model formulation:
  - E.g., ***Ln(RR)*** vs. ***RR***, ***Ln(O)*** vs. ***O***, ***Ln(RR)*** vs. ***Ln(1-RR)***

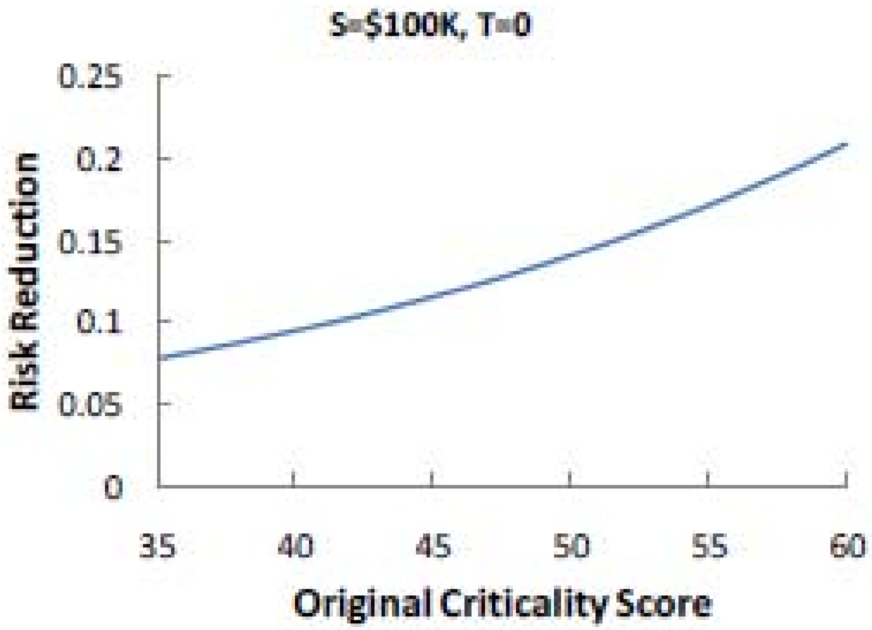
Findings

- For every $100K spent (all else equal), **17% less risk reduction** was achieved!
  - This does not imply that spending more money increases risk
  - Only that there is a wide variation in cost-effectiveness of investments between sites



Findings

- For every 10-point increase in the original criticality score (all else equal), **50% greater risk reduction** is achieved
  - In other words, sites with higher original risk tended to have more cost-effective improvements
  - "Low-hanging fruit"



Findings

- The two transportation sites were significantly less cost-effective than sites in the other sectors:
  - **65% less reduction in risk**, all else equal
- However, this observation should be treated with care:
  - Since there were only two transportation sites in the data set

Future Work

- We have enough experience by now with methods like TRAM to generate more complete and reliable data sets
- What is the next step in generating order-of-magnitude estimates of cost effectiveness for defense?

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